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Wetland Ecosystem Service Evaluation of Fenhe River

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Abstract

To improve the invironment of Fenhe River basin, river wetland ecosystem restoration project was planned. Four methods were applied in this paper to evaluate the wetland ecosystem services according to the plan, which were market value method, shadow project method, results reference method and expense payment method.The results showed that the total value was 234 million rmb yuan, in which the value of water purification was the biggest, accounting for 46.1%. However, as not all the functions were taken into consideration during the study, smaller result was produced. Meanwhile, according to the main functions of the five parts in the plan, their basic values were calculated. It suggested that the basic value was determined by both area and value coefficient. The third part Yi Dam to Er Dam had the highest value because of the larger area and the biggest value coefficient.

Keywords: wetland; ecosystem service; evaluation; Fenhe River

Introduction

Ecosystem service is defined as the conditions and processes meeting and maintaining human's needs supplied by natural ecosystem and its species. The evaluation of wetland ecosystem service is a evaluation process to convert the abstract service into appreciable price of money by taking evaluation methods[1]. Ecosystem functions and the values were classified into four (regulation, habitat, production and information) and three(ecological, socio-cultural and group) types, respectively[2]. The evaluation methods were classified into three types that were contingent valuation method, alternative market method and direct market method[3]. Ten main methods(market value method, production function method, opportunity cost method, shadow project method, productivity variety approach, human capital approach, travel cost method, hedonic value method, contingent value method and ecological value method) were compared by Fu and Ding[1]. Based on these methods, service functions of Sanyang wetland in Hangzhou, Maipo marsh in Hong Kong and Panjin Area were evaluated[4-6].

In this paper, riverside wetland ecosystem service values of hydrological adjustment, climate regulation, water purification, entertainments and life-supporting were evaluated by using market value

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method, results reference method, shadow project method and expense payment method. And basic values of the five parts in the plan were calculated according to their function orientations.

Background

The human activity intensity of Fenhe River basin is the biggest in Shanxi Province. In recent years, the health of riverside wetland ecosystem was threatened by both water resources quantity and quality because of flow reduction, overexploitation and sewage discharge. In order to solve the ecosystem issue, river wetland ecosystem restoration project was planned.

The wetland restoration project aimed to turn the existing wetland into normal state by supplying water resources to ecosystem, controlling the pollution and all restoration and management. Besides, constructed wetlands would be built in some important areas to exert their all functions and benefits furthest. The wetlands were planned 783 ha occupied area to build landscape along the river, wetland parks and water purificating sections. Table 1 gives the construction scheme.

Table 1 Construction scheme of Fenhe River wetland

No.	location	area[ha]	function orientation
1	Lancun~Chaicun Bridge	180	landscape, ecotourism area
2	Chaicun~Xiaodian Bridge	228	landscape, entertainment
3	Yi Dam~Er Dam	200	Constructed wetland, pollutants treatment
4	San Dam reservoir area	75	park, ecotourism area
5	Linfen City	100	park, entertainment

Methods

To compare the values of different services, total values of five areas were calculated. And to compare the values of different areas, the main services values of each area were calculated.

Based on the construction scheme, gained basic data, field edit investigation, the main service functions were evaluated by the following methods.

(1)Value of hydrological adjustment (V_1).Wetland ecosystem can storage water resources, accomodate the quantities of the wetland runoff and groundwater around. In floody seasons, the redundant water can be transported by the wetland to rivers and seas, which let the areas avoid flood losses caused by excessive water. Howere, in the droughty seasons, the water resources in the wetland can be used to irrigate.

Service function of hydrological adjustment can be evaluated by results reference method (see Eq.1).

$$V_1=A\times AU \quad (1)$$

Where A and AU are the area of the wetland and the value per area, respectively. The coefficient of value per area refers to the existing studies.

The coefficient AU referred Xie[7] and chose 13715.2 rmb yuan per hectare.

(2)Value of climat regulation (V_2). Plants in wetland can exchange CO_2 and O_2 with atmosphere by photosynthesis andrespiration, which keeps the O_2 and CO_2 balance in atmosphere.

This process produces two values. One is produced by O_2 dischaging, which can be evaluated by market value method. The value refers the cost of producing the same quantity of O_2 in factories. The other value is produced by CO_2 fixing which can be evaluated by carbon taxes method. It's a method that evaluates the fixed CO_2 according to the charging standards of CO_2 discharge in our country. Based on the photosynthesis equation ($6CO_2+12H_2O=C_6H_{12}O_6+6O_2+6H_2O$), producing 1gram of dry matter needs 1.62 gram of CO_2 and discharges 1.2 gram of O_2. Service function of climat regulation(V_2) can be evaluated by the following equation,

$$V_2=(1.6\times PC+1.2\times PO)\times PAS\times A. \quad (2)$$

Where PAS is the amount of dry substance produced per area, PC is the amount of tax to be paid for CO_2 discharging per ton,PO is the price of O_2 produced in factory.

Price of O_2 produced in factory was between 400 and 600 rmb yuan per ton, chose 600 here. The mean value of carbon taxes in international standard was 770 rmb yuan per ton. The amount of dry substances produced per hectare wetland was between0.57 and 10.0, chose 10 here.

(3)Value of water purification(V_3). Wetland ecosystem can purify the water resources by intercepting and absorbing the pollutants. The purification realizes by two means, one is direct assimilation by biology, the other is adsorbtion by soil particle and colloide.

Service function of water purification can be evaluated by shadow project method, one kind of replacement cost method that evaluates a replaceable project having the same functions as the ecosystem to be substituted. Here, a new water purification project was used to substitute the wetland ecosystem. The cost of the project was considered as the service value(see Eq.3).

$$V_3=\max(A\times W_i/N_i)\times P_i. \quad (3)$$

Where W_i is the amount of pollutant i removed per area of wetland ecosystem, N_i is the concentration of pollutant i in the water flooding into sewage disposal plant, P_i is the cost that one ton of sewage disposed by the sewage disposal plant.

The cost of sewage disposal was about 1 rmb yuan per cubic meter(containing preciation cost). The amounts of COD and ammonia nitrogen pollutants removal per square meter were 5.1g and 3.7g, respectively. And the influent concentrations of COD and ammonia nitrogen were 400mg/L and 25mg/L, respectively.

(4)Value of entertainments(V_4). This value mainly manifests in education, inspiration enlightening, aesthetics, cultural heritage, entertainment, ecotourism, etc.

Service function of entertainments can be evaluated by expense payment method, determined by person-time and per capita consumption in unit area of wetland conservation and parks(see Eq.4).

$$V_4=EP\times EPM\times A. \quad (4)$$

Where EP is tourism person times received per area of wetland,EPM is consumption per head.

According to the data of 2020 that the tourism income was 108.3 billion in the whole province and the tourist reception was 0.13 billion person times, EPM was equivalent to 860 rmb yuan per person time. Based on the existing reception capacity, 100 person time per hectare was chosen as the coefficient EP.

(5) Value of life-supporting(V_5). Wetland ecosystem has the functions of maintaining the natural ecological processes and regional ecological environmental conditions, such as soil formation and maintenance, oxygen production, nitrogen cycle, water cycle, primary productivity, habitat supply, etc. So, it has values of supplying habitat for significant species and driving nutrients cycle.

Service function of life-supporting can be evaluated by results reference method (see Eq.5).

$$V_5=EU\times A. \quad (5)$$

Where EU is the value of life-supporting per area.

Acording to the values of jamming adjustment (that is the responses of capacity, interference immunity and integrality of the ecosystem to fluctuations) and biological habitat (containing permanent and temporary habitats) per area given by Costanza[8], 42134.1 rmb yuan per hectare was chosen as the coefficient EU.

Results and discussion

(1)The total value was 0.23 billion rmb yuan, about 1% of the total tertiary industry output value in six cities the Fenhe River flowing through in the year of 2010. This value was relatively small for the reason

that the functions evaluated were not complete. The production value and some non-direct ecosystem values(such as the appreciation of real estate nearby) were not evaluated in the study.

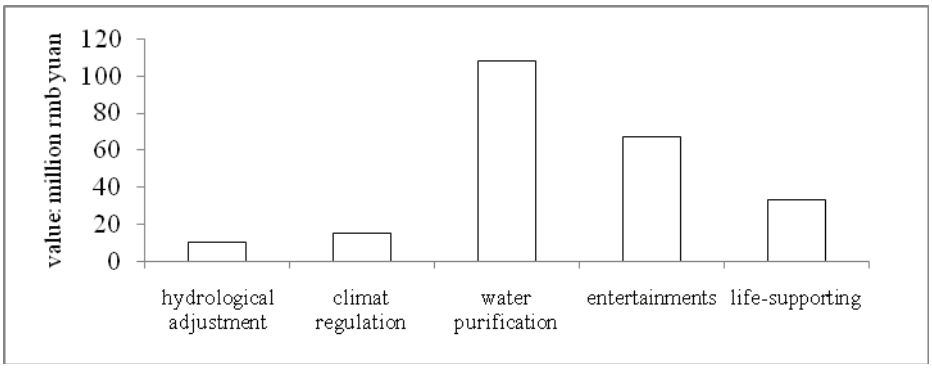

Fig.1 Total values of the five functions

(2) Fig.1 gives the results of total values of the five functions. Although different methods have been taken, the magnitude orders are same. So the values can be comprared. Fig.1 shows that the value of water purification is the biggest and about ten times big as that of hydrological adjustment. It is because that the cost of sewage disposal is much and the sewage disposal capacity is great. The constructed wetland wastewater treatment technology have been applied to dispose domestic sewage for years. Though the wetland can remove and reduce the pollutants efficiently, the function of water purification would be lost once the concentration exceeds the threshold. To keep the big value, wetland should be protected well.

(3) To compare the values of the five parts of the wetland, the main value of different functions were identified(Table 2).

Table 2 The main values of different functions

function	main value
landscape	life-supporting
ecotourism	entertainment
constructed wetland	water purification
park/entertainment	climate regulation

The function of hydrological adjustment is contained in all the parts so that it is not a main function in any part. The basic values of the five parts were calculated based on their function orientations(Fig.2).

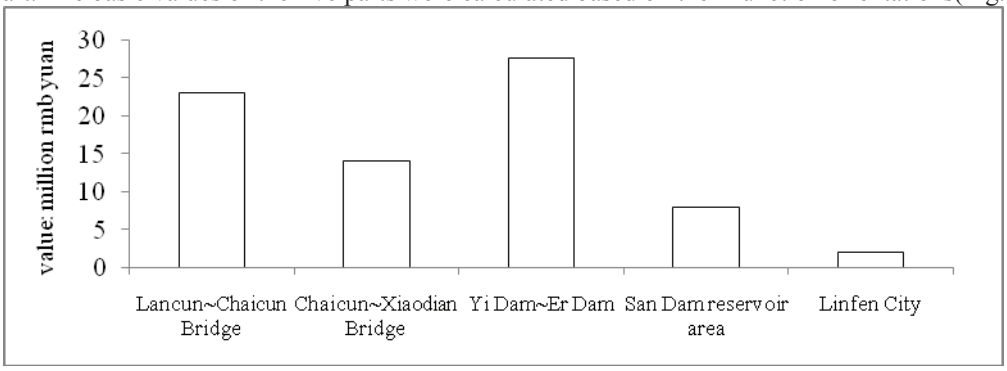

Fig.2 Basic values of the five parts of the wetland

Fig.2 shows that the value of the third part(Yi Dam~Er Dam) is the biggest and the fifth part(Linfen

City) is the smallest. It suggests that besides areas, the value is also determined by the functions. The part of constructed wetland has the biggest value because of the bigger area and the biggest value coefficient. The part of Linfen City has the smallest value coefficient and small area so that it has the smallest value. However, it also needs protecting because that it supplyed the citizens with a free pleasenting site which was not evaluated.

Conclusion

The five main functions of Fenhe riverside wetland ecosystem were evaluated by taking different methods according to the restoration project. The total amount of value was 0.23 billion rmb yuan in which the value of water purification was the biggest, accounting for 46.1%. The program would play a significant role in improve the water quality and the environment of Fenhe River basin. The basic value of the part Yi Dam to Er Dam was the biggest and that of the part Linfen City was the smallest. It suggested that the basic value of each part wetland was determined by both area and main functions. However, not all functions were considered and different influencing factors such as underlying surface were not analyzed. To get more rational evaluation results, evaluating motheds should be further devoloped from water cycle and energy cycle of matter.

Acknowledgements

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References

[1] FU Jiao-yan,DING Zhen-hua:Chinese Journal of Applied Ecology, vol.18(2007), pp.681-686

[2]Rudolf S.de Groo,Matthew A.Wilson and Roelof M.J.Boumans:Ecological Economics,vol.41(2002),pp.393–408

[3] YANG Li: Jonal of Huaiyin Teachers College, vol.23(2001), pp.624-628

[4] Wang Wei, Lu Jian-jian: Chinese Journal of Ecology, vol.24(2005),pp.1314-1316

[5] XIN Kun, Nora F.Y.Tam and Yuk-Shan WONG: Acta Ecologica Sinica, vol.26(2006), pp.2021-2026

[6] XIN Kun, XIAO Du-ning: Acta Ecologica Sinica, vol.22(2002),pp.1339-1343

[7] XIE Gao-di, Lu Chun-xia, CHENG Sheng-kui: Resources Science, vol.23(2001), pp.5-9

[8] Robert Costanza, Ralph d'Arge and Rudolf de Groot, in: The Value of the World's Ecosystem Services and Natural Capital, Natural Publishers(1987),pp.253-260